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Oakland Harbor Training Walls
(Oakland Inner Harbor Jetties)
Mouth of Federal Channel to Inner Harbor
Oakland
Alameda County
California

HAER No. CA-239

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
San Francisco, California

HAER
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HISTORIC AMERICAN ENGINEERING RECORD

OAKLAND HARBOR TRAINING WALLS
(Oakland Inner Harbor Jetties)

HAER NO. CA-239

Location:	The north wall begins at the mouth of the Federal Channel between Oakland Inner Harbor and San Francisco Bay, heading easterly approximately 7,400 feet along the north shore, Oakland, Alameda County, California USGS Oakland West, Calif. Quadrangle. Universal Transverse Mercator Coordinates : 10.559040.4183560 (West) 10.561200.418290 (East)
Date of Construction:	1874-1894
Engineer:	Colonel G. H. Mendell, District Engineer
Builder:	Numerous contractors supervised by U.S. Army Corps of Engineers
Present Owner:	U.S. Army Corps of Engineers San Francisco District 333 Market Street San Francisco, CA 94105
Present Occupant:	Port of Oakland
Present Use:	Shoreline stabilization (To be demolished 1999)
Significance:	The North Training Wall is one component of the Oakland Harbor Training Walls, which defined Oakland's basic harbor footprint and are the oldest surviving remnants of nineteenth-century harbor improvements. The walls are significant for their association with the initial U.S. Army Corps of Engineers program to improve Oakland Harbor and make it accessible to ocean-going vessels. The training walls are also associated with technological advances in dredging and represent a characteristic example of nineteenth-century dry masonry construction. In addition, the walls are an excellent example of the engineering abilities of Col. George Henry Mendell, District Engineer of the Corps of Engineers, San Francisco District, from 1871-1895.
Report Prepared by:	Celia McCarthy, Cultural Resources Planner Port of Oakland 530 Water Street Oakland, CA 94607
Date:	May 1999

I. DESCRIPTION

The Oakland Harbor North Training Wall is one of two stone jetties[1] placed 750-1000 feet apart and parallel to the federal channel of the Oakland Inner Harbor (Figure 1). The wall is constructed largely of locally quarried loose stone, described as "a flinty blue trap to a soft sandstone,"[2] which was allowed to take its natural slope under tidal action. The top and sides were faced with large stones, two to four feet in diameter, hand-set, with a dry masonry technique, giving the wall a finished appearance. Built over a 20-year period, the wall had risen to nine feet above Low Water, with a total length of 9,500 feet, by the time of its completion. Both training walls originally extended nearly two miles into the open bay, but extensive filling has created hundreds of acres of upland on the north side of the north training wall and the south side of the south training wall. Although sections of both walls have been covered with fill or destroyed, significant portions remain and are visible at most tidal levels.

Recent on-site examinations have established that the north wall is 12 to 20 feet wide at its base, approximately eight feet wide at the top, and rises approximately five to six-and-a-half feet above Low Water. The channel face and large sections of the top of the wall are visible. The landward side has been buried by fill, the grade of which is higher than the top of the wall. The stones are worn, as would be expected under constant wave action, and facing stones are missing in several places, revealing the smaller rubble construction beneath. The north training wall retains its original form in the sections that have not been removed or covered by fill.

The north training wall has a total length of approximately 7,400 feet, running from the western end of the Oakland Inner Harbor to the fishing pier at Middle Harbor Park (Figure 2). Beginning from the western end and heading east, the wall is visible and relatively intact for approximately 4,200 feet. Although an approximate 18-foot gap occurs at about 2,150 feet, and portions of the top are partially or completely covered by fill beginning at about 2,250 feet, the face of the wall remains visible. After 4,200 feet, the top and face of the north training wall are completely covered by riprap for a distance of about 1,200 feet to a culvert that has pierced the wall (which creates another approximate 18-foot gap). In 1990, following the Loma Prieta earthquake, the Union Pacific Railroad deposited riprap in this covered section due to concern over the stability of its tracks, which are approximately 15 feet from the edge of the grade in this section. Moving east beyond the covered section, the wall is again free of fill on the top and face for a distance of about 1,200 feet. The top of the easternmost section, which extends another 800 feet, is again covered in most places although the face is visible until the Middle Harbor Park fishing pier. Historically, the wall took an almost 90 degree turn to the north at this point to circumvent a ferry slip. Because the grade here is much higher than the original wall, there is a high probability that archaeological remains of this jetty section may be found buried under fill heading north for an additional 1,000 feet.

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[1] See page 10, paragraph 2, for an explanation of harbor wall terminology.

[2] Richard Lerner, "Oakland Inner Harbor Project History," U.S. Army Corps of Engineers, manuscript on file at USACE, San Francisco District, 1982 (44th Congress, 2nd Session, Doc. 1744, p.611). Most of the historical material on the Corps of Engineers' construction of the training walls comes from this summary of the Annual Report of the U.S. Engineer Office, San Francisco and is contained in the Secretary of War's Annual Report to congress. Subsequent footnotes will cite this summary as well as the original documents.

The north training wall is largely intact. It has remained in the same location since its completion in 1894. Although filling has substantially changed the setting, the channel remains clearly defined by the two training walls. Approximately 65 percent of the north wall is still visible, and it is assumed that an additional 23 percent is buried under fill. While some sections have deteriorated and small areas have been repaired, the portion of the wall that is visible retains a high degree of integrity, especially when viewed from the water or from the opposite shore of the harbor.

II. ENGINEERING INFORMATION

Training Wall and Channel Construction

Oakland was the first port in the Bay Area after San Francisco to receive the attention of the Army Corps of Engineers. W.F. Boardman, City Engineer for Oakland in the late 1860s, enlisted the aid of Colonel G.H. Mendell, who examined San Antonio Creek and affirmed the area's harbor potential (Figure 3). In response to intense local interest, Congressman Frank Page and Senator A.A. Sargent lobbied for funding in the River and Harbor Act of 1873, so that a special board of engineers, composed of Colonel Mendell, Lieutenant Colonel B.S. Alexander and Lieutenant Colonel C.S. Stewart, could survey and plan for harbor improvements.[3] Mendell had observed that the reciprocal action of the flood and ebb tides in San Antonio Creek created a channel 450 feet wide and 18 feet deep at the west end of the harbor. When the tidal currents lost their strength, due to the guiding (or "training") of the shores, a sand bar formed beyond the mouth of the harbor, impeding vessels with a draft over six feet (except during extreme high tides). A plan was devised to accentuate the tidal action by building training walls out to deeper water, where shoaling[4] was less likely to occur. In February 1874, the following improvements to Oakland Harbor were recommended:

1. Construction of two parallel submerged training walls, 1000 feet apart, and dredging of a channel 100 feet wide to six feet below Low Water between the walls. It was anticipated that natural scouring between the walls would deepen and maintain the channel to 12 to 14 feet below Low Water within one to two years.

2. Excavation of a canal to eight feet below Low Water between San Antonio Creek and San Leandro Bay to increase ebb tide flushing of the San Antonio channel.

3. Construction of a dam with tidal gates across the mouth of San Leandro Bay to force most of the San Leandro Bay ebb tide through the canal, flushing the San Antonio channel.

4. Excavation of a tidal basin at the east end of the harbor to two feet below Low Water to provide additional ebb-tide flushing.

5. Maintenance dredging of the channel to enable the largest ships to enter the new harbor.[5]

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[3] A. Henry. "History of the Improvement of Oakland Harbor," *Oakland Enquirer*, XLIII: 101, October 24, 1903, 1.
[4] *Shoaling* – loss of water depth due to the buildup of sand or silt.
[5] Lerner, 43rd congress, 2nd Session, Doc. 1636, pp. 378-385.

It was estimated that the improvements would cost $1,815,000 and require 30 years to complete.[6] Work began in 1874 by marking the line of the north training wall with piles, surveying the canal route, and opening a quarry on Yerba Buena Island. Between 1876 and 1884, construction activities in the project area consisted of placement of rock for the training walls and dredging of the channel between them. By 1900, the channel was 300 feet wide and 20 feet deep at low tide as far east as the Webster Street Bridge, where it divided into smaller channels. The tidal basin covered 300 acres to a depth of two feet at low water. Excavation of the tidal canal began in 1889 and ended in 1903, bringing the overall project to a close (Figure 4). The tidal dam, later deemed unnecessary, was the only component of the 1874 plan that was never built.

The training walls were constructed of "pierres perdues," or loose stone, which took their own slope under the action of gravity, waves, and currents.[7] Stone came from the Yerba Buena quarry and other local quarries at Second Street and Telegraph Hill in San Francisco, Angel Island, San Bruno, and Point Pedro in San Pablo Bay (Figure 5).[8] Light-draft barges, or lighters, transported stone from the quarry to the construction. The quantity of stone on each barge-load was determined by means of displacement.[9]

By 1877, within three years of authorization, the training walls were already being referred to as jetties. Although both north and south walls were said to be complete in the 1878 U.S. Engineer report, it was also reported that the west end of the channel was not being scoured sufficiently, and raising of the walls was recommended. In addition, vessels were experiencing navigational difficulties due to a lateral sweep of water across the jetties. This made the channel dangerous for sailing craft, which tended to veer toward the north wall (on the ebb tide) or the south wall (on the flood tide) when winds were light.[10]

Work was suspended between 1879 and 1880 because title to the estuary bed and training wall sites was disputed. The River and Harbor Acts of 1878 and 1879 stipulated that funds would not be forthcoming until this issue was resolved. In 1880, title was cleared in an opinion rendered by the U.S. Attorney General, who found that according to the Doctrine of Navigational Servitude, the United States has supreme control of navigable waterways up to the line of the salt marsh.[11]

Work resumed in 1880. Revised construction plans called for the north wall to be raised above High Water and the south wall to five feet above Low Water. Dry masonry facing began to be set by hand on the upper levels of the jetties, which necessitated adding a footwall[12] upon which the dry masonry could be set for the north wall. No footwall seems to have been required for the south jetty due to the accretion

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[6] Joseph H. Hagwood, *Engineers at the Golden Gate*. San Francisco: U.S. Army Corps of Engineers, 1982, 104.
[7] Lerner, 45th Congress, 3rd session, Doc 1744, p 611.
[8] References to various quarries occur throughout the Annual Report of the U.S. Engineer Office, San Francisco, 1874-1894. For a table listing contractors and quarries, see Appendix A.
[9] G.H. Mendell, Extract from the Annual Report of the Chief of Engineers to the Secretary of War, Appendix RR, Washington, D.C.: Corps of Engineers, 1894, 2503. *Displacement* – the weight or volume of water displaced by a ship (or other floating vessel).
[10] *Mining and Scientific Press*. San Francisco: Dewey Publishing Co., XLII, 8:120.
[11] Ibid.
[12] *Footwall* - the foundation of an inclined wall.

of sand following construction.[13] Floating derricks with 60-foot booms were used to lay the facing stones.[14]

The decision to use local stone for the facing (instead of concrete, considered the best and most permanent construction) was a cost-saving measure. Large stones were a product of the quarrying operation. Engineers in charge of the project thought that by utilizing the larger stones (which generally averaged from one-half to three tons in weight) to face the walls, the project could be completed more rapidly while staying within the appropriation. "The stones were all laid as headers, i.e. the longest dimension at right angles to the slope, and fitted closely together by hand labor, and all the voids well chinked up with small stone."[15] Mendell expressed the opinion that this construction technique would be adequate for the present, and that if a concrete wall was deemed necessary "the future can pay for it."[16] Jetties (like breakwaters, revetments, and similar wave protection structures)[17] are usually constructed of large, free-form stones with many faces and voids to dissipate wave energy. On the Oakland jetties, the facing stones were placed closely together by masons to provide a high degree of interlocking, producing greater strength with smaller, lighter stone. While less expensive in terms of materials, this technique requires a high level of skill; because it is labor intensive, the practice has become economically impractical. Few, if any, examples of this type of maritime construction survive today.

Even before they were completed, the jetties were considered significant. An 1881 report in *Mining and Scientific Press* noted: "Some idea of the extent of this great engineering enterprise may be realized when we state that the two jetties, which are nearly parallel, extend from the shoreline out into San Francisco Bay a distance of 12,076 ft. This is 1,000 ft. longer than the jetties built by Capt. Eads at the mouth of the Mississippi River."[18] As work continued on the jetties, they rose six feet to nine feet above Low Water, which is about one foot above the highest spring tides.[19] Contractors continued to apply dry masonry facing to both the north and south jetties. A total of 311,101.32 tons of stone was used. The walls were declared complete in a July 1896 report.[20] Other sources indicate that construction actually ended in 1894.[21] The training walls have had few alterations since their completion. A 1919 report noted: "They are free from deterioration, due to careful construction and general absence of disturbing factors and they need no maintenance."[22] Recent alterations are discussed above in the "Description" section.

[13] Lemer, 50th Congress, 2nd session, Doc. 2631, p. 2419.
[14] Mendell 1894, 2503.
[15] Lerner, 53rd Congress, 3rd session, Doc. 3299 p. 2501.
[16] L.J. LeConte. *Recent Dredging Operations at Oakland Harbor, California*. New York: American Society of Civil Engineers, 1884.
[17] *Breakwater* - an engineering structure to afford shelter from wave action; may be called mole, jetty (Atkins 1983). *Revetment* - a facing of masonry or the like especially for protecting an embankment (Webster's 1996).
[18] *Mining and Scientific Press*, XLII, 8:120.
[19] Lerner, 50th Congress, 2nd session, Doc. 2631, p. 2419.
[20] Lemer, 55th Congress, 2nd session, Doc 3488, p. 3173.
[21] "No work was done on either jetty" during the 1894-95 fiscal year - Mendell 1895 p.3249. No work was reported done in 1895-96, Suter 1895, p. 3174. "The jetties were completed in 1894" - Lerner, 30 June 1919, p. 1759; pp. 3386-8.
[22] Lerner, 30 June 1919, p. 1759; pp. 3386-8.

III. HISTORICAL INFORMATION

Community History

The training walls made Oakland's waterfront accessible to ocean-going vessels. The necessity for harbor improvements had been recognized soon after the Oakland was chosen as the western terminus of the Central Pacific Railroad's transcontinental line in 1869. The training walls greatly enhanced the harbor's capacity for transportation and commerce. Cargo entering and leaving the harbor increased from 154,000 tons in 1874 to about 3.25 million tons by 1900. The walls also acted as borders for hundreds of acres of landfill deposited between 1874 and 1946. The enhancement of Oakland's marginal natural harbor exemplifies the important role played by the U. S. Army Corps of Engineers' in 19th-century California. Establishment and maintenance of a deep-water channel in the Oakland Harbor laid the foundation for one of the nation's leading ports. The training walls played a crucial role in this transformation because their construction was the first project in a comprehensive program of harbor improvements.

In its natural state, prior to improvements, the Oakland waterfront was flat and marshy, with extensive tidelands that became mudflats at low tide. San Antonio Creek meandered east from San Francisco Bay approximately three miles, terminating in a broad shallow basin (the location of today's Brooklyn Basin and Coast Guard Island).[23] The value of the waterfront in this area had been recognized much earlier by Native Americans, who left nearly sixty shellmounds on the shores of Alameda County, and by the Spanish, who needed access to navigable water to ship hides and tallow, the chief export products of their ranchos. In 1820, approximately 44,800 acres of the *contra costa*[24] was granted to Louis Maria Peralta, a soldier from San Francisco's Presidio. This was one of the largest and oldest land grants in Northern California. Present-day Oakland lies within the historic boundaries of the Peralta family rancho.[25]

San Francisco Bay is the most important natural sheltered harbor on the Pacific Coast. During the Gold Rush (1848-1853), San Francisco was transformed from a tiny settlement into a metropolis of over 50,000 residents. At the same time, several small communities were founded on the east side of the bay, including Oakland, Alameda, Brooklyn, Clinton and San Antonio. Of these, Oakland was the principal town. At the first meeting of the town trustees, on May 17, 1852, Horace Carpentier, one of the town founders, gained the exclusive right to construct wharves, piers and docks within the town limits and to collect wharfage and dockage at such rates as he deemed reasonable. Carpentier's ownership of the shoreline was challenged in court repeatedly but it was not until 1909 that the city gained control over its waterfront.[26]

[23] Woodruff C. Minor, "Historical Overview." Working paper, Basin Research Associates, San Leandro, California, 1997, 1.
[24] *Contra costa* - Spanish for "the opposite shore."
[25] Beth Bagwell, *Oakland: The Story of a City*. Oakland, CA: Oakland Heritage Alliance, 1982, 8-13.
[26] Settlement of this dispute came after considerable wrangling between the railroad, the city and the federal and state governments. A good discussion of the whole process can be found in Bagwell, 186-189.

The "Compromise of 1868" brought the railroad terminus to Oakland by transferring Carpentier's title to the Oakland Waterfront Company (controlled by railroad interests). Trains of the Central Pacific Railroad began to bring passengers and freight to Oakland in 1869. By 1871 Central Pacific's Long Wharf reached two miles into the bay off Oakland's western waterfront to deep water. The Long Wharf remained Oakland's principal shipping terminal through the 19th and early 20th centuries.[27]

Harbor Improvements and Waterfront Development

Despite Oakland's tenuous hold on its own waterfront, city officials and business interests pushed hard to gain federal support for the improvement of the harbor. Under the Constitution, river and harbor improvements are the responsibility of the federal government. This responsibility has been delegated to the U.S. Army Corps of Engineers. Federal harbor improvements in Oakland began in the 1870s. Details of this project are described above in the "Training Wall and Channel Construction" section.

The San Francisco District of the U.S. Army Corps of Engineers was established in 1866, with authority for all river and harbor work in the western United States and Hawaii. The district covered the entire area from the Rocky Mountains to the Pacific Coast between the Mexican and Canadian borders. This vast district soon began to be split into smaller districts. The Portland District was founded in 1871, followed by the Seattle District (1896), Los Angeles District (1898), and Honolulu District (1905). By 1907, the San Francisco District was limited to portions of California and Oregon. In that year, the district was divided in two; the inland district, comprising the Central Valley, became known in 1925 as the Sacramento District. Today the San Francisco District covers a strip of coastal land extending north from Big Sur to the Oregon border, with an inland spur at the north end.[28]

The harbor improvements overseen by the U.S. Army Corps of Engineers affected Oakland and Alameda in several ways. First, and most obviously, the improved navigability stimulated shipping and contributed greatly to waterfront development. By the 1880s fleets of whaling barks were laid up in the harbor, and by the turn of the century the Alaska Packers Association, the world's largest salmon-packing concern, moored and repaired its vessels there. The harbor also became an active shipbuilding port, with extraordinary bursts of productivity during the two world wars. Canneries, mills, factories, foundries, lumberyards, and coal bunkers proliferated. During the first 26 years of harbor improvements (1874-1900), waterborne commerce increased twenty-fold.[29]

Shipping expanded dramatically after 1910, when Oakland's municipal government wrested control of the waterfront from the Southern Pacific Company (successor to the Central Pacific). By the early 1920s, city-owned wharves and transit sheds dotted the shoreline from Brooklyn Basin to the western tidelands. After 1925, the newly established Port of Oakland constructed larger and more extensive facilities along the Inner and Outer harbors. Since the 1960s, nearly all of the Port of Oakland's

[27] Hagwood, 56.
[28] Ibid.
[29] Woodruff C. Minor, "The Many Histories of the Oakland-Alameda Estuary." *The Museum of California Magazine* 20 (4), 1996.

terminals have been converted to container technology.[30]

Less obvious, perhaps, has been the impact of the harbor improvements on the geography of the waterfront. There have been three principal impacts, stemming from the excavation of the tidal canal, the construction of the training walls, and channel dredging. The tidal canal extended the waterfronts of Oakland and Alameda, in the process transforming Alameda into an island. The construction of the training walls created new shorelines as the tidelands behind the walls were filled in. Finally, the continual dredging produced tons of material used to fill in the tidelands and marsh to create new shorelines. The highly developed waterfronts of present-day Oakland and Alameda are the result of this continuous reclamation process.[31]

The training walls led to the creation of solid-fill "moles" which in turn served as the edges for extensive reclamation projects. On the Alameda side, the South Pacific Coast Railroad (SPCRR) built a long ferry pier south of and parallel to the south training wall in the early 1880s. The Southern Pacific, which took over the SPCRR, proceeded in the 1890s to fill in the area between the pier and training wall, creating the Alameda Mole.[32] Naval Air Station, Alameda was created in the 1930s by filling in the remainder of the tidelands south of the Alameda Mole.[33] On the Oakland side, the training wall formed one edge of the Western Pacific Mole, constructed in 1909-10.[34] The tidelands to the north of this mole were filled in the 1930s and 1940s to create the Oakland Naval Supply Center (later known as the Fleet and Industrial Supply Center Oakland). Today, both training walls continue to be major definers of the Oakland and Alameda shorelines (Figures 6-8, Photos CA-xxx-30 through 35).

Technological History

The design and construction of the Corps' 1874 harbor improvement project in Oakland took place within an international context. Publications in a variety of languages from this period indicate that harbor engineering all over the world was undertaken by an international community of engineers, who were aware of harbor improvements designed by their colleagues in other locations. The purpose and design of the improvements in Oakland was similar to projects in other areas. Construction methods for these projects probably had not changed much since ancient times.

A harbor is defined as a protected area that provides a place of safety for vessels and the general purpose of most harbor structures is protection against waves, tides and currents. Phoenicians built "moles of

[30] Brady & Associates and Woodruff C. Minor, "Historic Resources." Administrative Draft Environmental Impact Report for Charles P. Howard Terminal Extension. Prepared for Port of Oakland, 1994, 61-80.
[31] Minor, 1997.
[32] Woodruff C. Minor, "A Maritime History of Alameda: The South Pacific Coast Railroad." *Alameda Journal*, October 7-13, 1988.
[33] Woodruff C. Minor, "Air Alameda: NAS Alameda—Buildup and War." *Alameda Journal*, April 7-10, 1995.
[34] Louis S. Wall and James P. Delgado. Assessment of Eligibility for National Register of Historic Places: Deteriorated Marine Facilities, Western Pacific Railroad, Oakland and San Francisco, California. Prepared for the Union Pacific System, 1985.

loose or random rubble"[35] by 2000 BC and the Egyptians, Greeks, and Romans possessed a highly developed understanding of harbor engineering. Harbor improvements are as old as navigation but their purpose and design increased in complexity as shipping dispersed, larger ships were built, and harbors were established outside of the Mediterranean in areas with larger tides.[36] The harbor works at Le Havre in the 16th century dealt with similar problems to those faced by Oakland. Engineers applied "a coordinated system of jetties, shore protection lock gates and basins that overcame a tidal range of 25 feet. Shoaling was effectively checked by gates on the river entering the harbor which could be closed at high tide and reopened at low tide to let the rush of water scour the bottom of the harbor."[37]

By the second half of the nineteenth century, significant advances had been made in the field of hydraulic engineering. The development of harbor works was dominated by five main features: 1) the growth of seaborne trade and the size of ships; 2) the creation of harbor facilities near centers of industry and commerce; 3) the application of steam power to cranes, pile drivers and dredges; 4) improvements in materials; 5) a growing appreciation of the importance of the study of tides, waves and currents.[38] Rivers and harbors and the adjacent landscape were receiving wholesale modification during the first half of the century on the East and Gulf Coasts of the United States. This continued during the second half of the century, as the railroad pushed west and opened the Pacific Coast to transcontinental transportation routes. Detailed by the Constitution and authorized by subsequent Rivers and Harbors Acts, river and harbor improvement projects were initiated and supervised by the Army with the encouragement and cooperation of city and state governments.[39]

Training walls represented state-of-the-art 19th-century engineering attempts to control and use natural tidal currents to scour and deepen channels, and had been in use for some time during the nineteenth century. The earliest effort in England was by John Smeaton at Ramsgate in 1779. In 1858, work began at the mouth of the Seine on a plan which included a pair of parallel training walls[40] and in 1862 work began in Rotterdam on a system with components similar to those in Oakland including parallel training walls, a dredged channel and a dam to contain water brought in by the high tide for gradual release in order to scour the channel.[41] Similar systems continued to be built into the early 20th century at locations around the world including Fen Rivers, Great Britain (begun 1870), the Mississippi River (begun 1874), Oakland (begun 1874), Dunkirk, France (begun 1875), Madras, India (1870s), Tampico, Mexico (begun c.1900), Ostend, Belgium (begun c. 1904), and Venice (begun c.1905). These systems included training

[35]Brysson Cunningham, *A Treatise on the Principles and Practice of Harbor Engineering.* London: Charles Griffin and Company and Philadelphia: J.B. Lippincott Company, 1908, 1.
[36] Ibid, 1-5.
[37] Richard Shelton Kirby, Sidney Withington, Arthur Burr Darling, and Frederick Gridley Kilgour, *Engineering in History.* New York: McGraw-Hill, 1956, 144.
[38] J. Allen, "Hydraulic Engineering," *A History of Technology: Volume V, The Late Nineteenth Century, 1850-1900.* Charles Singer, et al, Ed. New York and London: Oxford University Press, 1958, 539.
[39] Eric Monkkonen, *America Becomes Urban: The Development of U.S. Cities and Towns 1780-1980.* Berkeley, Los Angeles, and London: University of California Press, 1988,128-30.
[40] Cunningham, 1908, 227.
[41] Thomas Colclough Watson, "On the Use of Fascines in the Public Works of Holland", Paper No. 1415. *Minutes of Proceedings of the Institution of Civil Engineers,* vol. 41. London , 1875, 166.

walls, dredging, tidal or sluicing basins[42] to enhance the flow at ebb tide, and a dam or channel gate. As more systems were built and as dredging technology improved, training walls, sluicing basins and other means of augmenting flow were employed with decreasing frequency while the use of dredging increased. By 1900 sluicing basins were generally considered obsolete.[43] In Oakland, the decision to abandon the construction of a dam across the San Leandro Bay reflected a better understanding of the situation and a shift toward dredging, rather than failure to complete the project. Dredging has continued to grow in importance as a means of maintaining shipping channels in the 20th century.[44]

Dredging

Historical records indicate that dredging of a channel 100 feet wide began in 1877. The largest ship to enter the Oakland Harbor that year was a French bark drawing 14 feet.[45] In 1878, dredging of a 200-foot channel to 10 feet resulted in 222,341 cubic yards of material, which was hauled by scows to six fathoms depth and disposed of in the deep water of the San Francisco Bay.[46] Dredged material began to be deposited to fill the marsh behind the north wall in 1882. By 1903, deposition of dredged material had resulted in a "no man's land" - more than 100 acres of filled or "reclaimed" land built along the north jetty by dredgers.[47] In 1883, a new system of hydraulic dredging began to be employed in the Oakland Harbor. Hydraulic pipeline dredges were first demonstrated in Europe and the United States during the 1850s and gradually gained acceptance in the 1860s when they were used in the Grand Canal Works, Amsterdam, the largest mechanical dredging project in the world to that time. In 1864, William Freeman and James Burt, two British contractors, patented a system that was a combination of mechanical dredging and hydraulic pipeline discharge for pumping dredged material ashore through a floating, flexibly connected pipeline. An all-hydraulic system was first used on the Amsterdam project in 1871.[48] The first successful hydraulic dredge in California appeared in 1879 and was built in San Francisco to raise levees at Union Island in the Lower San Joaquin Valley.[49]

Colonel Alexis W. Von Schmidt, a civil engineer, had been working on a hydraulic dredge with a floating pipeline for a number of years. The original discharge system of the Von Schmidt dredge consisted of an 18-inch pipeline that extended outboard for a distance of 20 to 89 feet. In 1883, Von Schmidt's Improved Dredging Machine was built in San Francisco by the Golden State and Miners' Iron Works for Von Schmidt, who operated it in harbor dredging and land filling for over 20 years.[50] In

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[42] *Tidal or sluicing basin* - an artificial body of water open to a river, stream, etc., subject to tidal action (Webster's 1996).

[43] Alfred Edward Carey, "The Sanding-up of Tidal Harbours." *Minutes of Proceedings of the Institution of Civil Engineers*, 26 January 1904, vol. 156, p. 215-302 London, 1904, 216 & 290-291; Cunningham 1908, 238.

[44] Michael Corbett, "Context - Criterion C: Harbor engineering and construction." Working paper, Basin Research Associates, San Leandro, California, 1997.

[45] Lerner, 44th Congress, 3rd session, Doc. 1796, p.985.

[46] Ibid, 45th Congress, 3rd session, Doc 1845, p.1283.

[47] *Oakland Herald*, "No Man's Land at Harbor Door Waits Oakland's Claim," Oakland, CA, April 18,1903.

[48] David Bastian, "Invention of the Pipeline," *World Dredging and Marine Construction*, 26:6, June 1985, 26-28.

[49] John Thompson and Edward Dutra, *The Tule Breakers: The Story of the California Dredge*. Stockton, CA: University of the Pacific and the Stockton Corral of Westerners, 1983, 48.

[50] Thompson & Dutra, 33, 48-53.

Oakland Harbor in 1883 this novel system of dredging was used to move dredged material ashore through a twenty-inch diameter conduit of iron pipe for distances up to 1,250 feet and lifts up to 12 feet. By 1884 the Oakland Harbor project exceeded its own record by transporting dredged material ashore up to 4,100 feet. These distances were considered worthy of attention because, at the time, they were the largest in the recorded history of dredging,[51] and by 1888 the record was broken again when the distance increased to 4,600 feet. Previously, William Freeman and James Burt, two British contractors, had employed a bucket and ladder dredge with a hydraulic pipeline discharge at the Grand Canal Works project in Amsterdam. They were able to transport dredged material up to 1000 feet with lifts up to eight feet but the material had to be handled twice.[52] One of the reasons Von Schmidt's system, as employed in the Oakland Harbor Project, was considered so novel is that it involved a one-step, single engine method of dredging and disposal of dredged material. The single-step process reduced the cost of moving material from 24 cents per cubic yard to a maximum cost of 10 cents per cubic yard. Today, 4,100-4,600 feet is considered long for a hydraulic pipeline without the aid of a booster pump. With boosters, material is now being pumped several miles.[53] L.J. Le Conte's account of the successful trial of the hydraulic pipeline dredge in the Oakland Harbor reached a national audience at the American Society of Civil Engineers in December, 1883, and three similar craft were in operation by 1893, contributing to major landfill projects in Washington, D.C., Norfolk, Virginia and Bridgeport, Connecticut. Similar cases were reported at Buenos Aires, Argentina and Melbourne, Australia.[54]

Harbor wall construction

The design of harbor walls appears to have changed little from ancient times to the 19th century when new possibilities were developed. The terms breakwaters, jetties, training walls, moles, and piers have been used interchangeably at times. A training wall is usually built as part of a pair and its purpose is to concentrate the flow of water to scour a channel. A jetty juts out from land. A breakwater may not be attached to land at either end. A mole still juts out from land but it usually has a flat surface, which can be used as a transfer point for freight or passengers between land-based and water-based transportation. In contrast, wharves and quays run along the shoreline, may serve as retaining walls, and are specifically for loading and unloading vessels.[55] In Oakland, the change in the term from training walls to jetties may simply reflect the change in their primary purpose, from enhancers of tidal scouring to safeguards against waves and currents inside the harbor.

Harbor walls were designed in two different ways, sometimes in combination — as rubble mounds and as walls. Sometimes only a rubble mound is built; sometimes the rubble mound serves as a base on which a masonry wall is built. While a breakwater often has a masonry superstructure which breaks waves, training walls are usually "merely mounds of rubble stone."[56] A rubble mound will eventually fall apart from the movements of the sea unless it is faced with a paving stone. Training walls

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[51] Lerner, 48th Congress, 1st session, Doc. 2185, p. 2527.
[52] Bastian, 28.
[53] Ted Bruch to Richard Lerner (personal communication), San Francisco, April 1996.
[54] Thompson & Dutra, 50.
[55] Brysson Cunningham, *A Treatise on the Principles and Practice of Dock Engineering.* London: Charles Griffin & Company and Philadelphia J.B. Lippincott Company, 1904, 268-269.
[56] Cunningham 1908, 231.

characteristically settle at the offshore ends and must be augmented with new stone if the relationship of the height of the walls to the tide levels is to be maintained. The height of training walls is an issue faced in every harbor project. Lower walls admit more water on the incoming tide, which then creates a more powerful scour on the way out. However, if the tidal flow contains much sand it diminishes the net effect of the tidal scour.[57] In some instances a phased addition of stone to a rubble mound served a couple of unrelated purposes. In addition to making up for settling, it helped in establishing new ground outside the channel: "When land reclamation was a desired outcome, training walls were first laid up to mean tide level, and then gradually raised until the level of highest high water is reached."[58] In Oakland, by the late 1880s, disposal of dredge spoils was made outside the training walls which, at the time, were being raised.

The construction of rubble mounds for training walls was usually uncomplicated - a 19th century method of a very old practice. No dredging or site preparation was necessary, other than to establish a means of sighting the line of the wall accurately. In Oakland, this was done with a line of piles. Rock was obtained from quarries near water and brought by barges to the site. Rock at the quarry was loaded in carts on rails, run downhill to a small wharf, and loaded by crane onto barges. At the site, barges dropped the rock through hoppers onto the line of the wall, or the rock was dumped or thrown overboard.[59] In a rubble mound, the rubble was permitted to assume its own slope determined by the intensity of the wave action and of the dimensions of the rubble. In Oakland, "loose stone (was) thrown on the lines and allowed to take its slope."[60] Once dumped, the rubble mounds were "trimmed" — made regular and level — by means of a sounding lead[61] and the handwork of divers and other workers. If this wasn't done, eddies, created by irregularities in the wall, would destroy it.[62]

The character of the rock helped determine the way the mound was built. The standard was "pierres perdue" or rubble (irregular stones from a quarry), which were generally used in the construction of large breakwaters.[63] The stone required a high specific gravity in order to resist the movement of the water. The stone for Oakland's training walls from Yerba Buena quarry was noted as having a specific gravity of 2.7 to 2.4,[64] indicating that this was a consideration of the engineers. In 1883, the structure of the unpaved portions of the walls were referred to as "a simple riprap wall"; "a rough flat slope of large stone riprap", and "large stone riprap."[65] Riprap was defined by Sturgis, the standard turn-of-the-century source, as "broken stone more irregular in shape and size than rubble", and a riprap wall as "a stone wall

[57] William Wright Harts, "Harbour Improvement on the Pacific Coast of the United States," Paper no. 3855. Minutes of Proceedings of the Institution of Civil Engineer, vol. 183. London: 1911, 240.
[58] Cunningham 1908, 234.
[59] Ibid, 149-151.
[60] Lerner, 45th Congress, 3rd session, Doc. 1845, p.1283.
[61] *Sounding lead* – a line, wire, or chord, weighted at one end and used to measure depth (Webster's 1996).
[62] Cunningham 1908, 151.
[63] James R. Ayers, "Harbor and Breakwater," in *The American People's Encyclopedia.* Chicago: the Spencer Press, 1953, vol. 10, p.10-184 to 10-188; Michael Scott, "Description of a Breakwater at the Port of Blyth; and of Improvements in Breakwaters, applicable to Harbours of Refuge". *Minutes of Proceedings of the Institution of Civil Engineers.* vol. 18, London 1859, 105.
[64] Lerner, 44th Congress, 2nd session, Doc. 1744, p. 611.
[65] Lerner, 48th Congress, 1st session, Doc. 2185, p.1961.

without regularity of structure; as used in deep water."[66] Oakland's walls were faced with large stones, laid up in dry masonry between 1881 and 1895. An unfinished rubble mound wall is more susceptible to deterioration from wave action and requires more maintenance, while a paved wall actually requires less stone and takes up less space.[67] The dry-laid masonry used to face the jetties is their most distinctive aspect and sets them apart from other similar structures, which today are usually rubble walls without a finished facing. Examples of these types of walls are illustrated in the literature, including Cherbourg, shown in 1858-1859 and Plymouth, shown in 1859-1860,[68] in Europe. In America, the following have strong similarities to Oakland: Delaware (1828), Point Judith, Rhode Island (1891), Delaware Bay (1897), San Pedro, California (1898), and Colon, Panama (1910).[69]

Variations on this basic 19th century type were walls built generally after 1850 with blocks of concrete in place of stone. These could be built in place of much larger blocks without the trouble and expense of quarrying and transporting stone. Two important alternative methods of constructing rubble mound harbor walls were developed. The first involved the construction of "staging", a wood structure in the line of the wall on which cars ran on rails and from which stone was dumped straight into the water.[70] A second method, first used at Yaquina Bay, Oregon, involved dumping stone into layers of brush mattresses. These were later used at Humboldt Bay and around the world.[71]

In summary, the training walls in Oakland's harbor, designed in 1874 and built before 1900, are characteristic of an important type of harbor structure which was built around the world. In overall concept, in the material used and in the method of construction, the Oakland Harbor North Training Wall is an important and representative example of the type. Because many were built in rougher seas than San Francisco Bay — in the Pacific Ocean, the English Channel, the North Sea — most have been destroyed or replaced. A comparable project was attempted in Humboldt Bay beginning in 1889. These jetties, approximately 8,000 feet long, were built in much rougher seas and only survived until 1907; they have since been rebuilt twice.[72] The jetties in Oakland have the advantage of a milder environment and have survived relatively intact. Although no inventory of these structures has been made, it seems likely that those, which survive, are in relatively protected areas such as San Francisco Bay, the Great Lakes, and the Mediterranean. The Oakland training walls appear to be rare surviving examples of a once widespread type.

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[66] Russell Sturgis, *Illustrated Dictionary of Architecture and Building.* Unabridged reprint of 1901-1902 edition. New York: Dover Publications, 1989, 295.
[67] Curtis McD. Townsend, *The Hydraulic Principles Governing River and Harbor Construction.* New York: The MacMillan Company, 1922, 148.
[68] Townsend, 148; Scott 1859, plate 2; Michael Scott, "On Breakwaters". Part II, Paper No. 1028. *Minutes of Proceedings of the Institution of Civil Engineers.* vol. 19, p. 644-674. London 1860., plate 8
[69] Brysson Cunningham, *The Dock and Harbor Engineers Reference Book.* London: Charles Griffin and Company and Philadelphia: J.B. Lippincott Company, 1914, 75-75.
[70] Cunningham, 1908, 151.
[71] Cunningham, 1914, 283; Harts, 243.
[72] Hagwood, 175-185, 345-351.

Colonel G. H. Mendell

George Henry Mendell, Colonel, U.S. Army, was born on October 12, 1831, in Youngstown Pennsylvania. After his early education, Mendell received an appointment to West Point and graduated with honors on July 1, 1852. He first served as an assistant engineer on the survey of the Northwestern Lakes from 1852-54. From there, he became a member of the staff of Major General John Wool and participated in the railroad survey from San Francisco to Fort Yuma. Mendell then went to the Pacific Northwest, where he supervised military road construction and fought Indians. Following this assignment, he returned to West Point as a professor until the outbreak of the Civil War.[73]

Mendell served the early part of the Civil War as a topographical engineer on staff assignments. After his transfer to the Engineers, he was soon in charge of a four-company battalion which served with the Army of the Potomac, and was distinguished in the campaigns at Manassas, Petersburg, and Richmond. Following the war, he returned to West Point and resumed his professorship.[74]

In 1867, Mendell returned to the West Coast, where he would remain for the rest of his life. He was placed in charge of the fortification at Lime Point (now Fort Baker), San Francisco, and immediately demonstrated his ability to conduct large-scale projects using innovative engineering techniques. Mendell's first California innovation was to use a quicker and more economical approach to excavation of a steep, rocky hill at Lime Point. His approach called for a system of mines dug deep into the cliff, which were packed with several thousand pounds of explosives. The idea was to blast the entire face of the cliff away with just a few massive charges. When the explosives were detonated, no sound was heard and just a small amount of smoke and flame were observed through a moving mass of rock as the entire face of the hill in front of the charges fell into the sea.[75]

Mendell assumed command as District Engineer of the San Francisco District of the Army Corps of Engineers in 1871, and continued in that position for twenty-four years until his retirement in 1895. When the United States was divided into five Engineer divisions in 1888, Mendell was elevated in rank to lieutenant colonel and placed in command of the Pacific Division, which extended from the Mexican to the Canadian Border. He served as both Division Engineer and San Francisco District Engineer for the rest of his military career.

During the time Mendell served in San Francisco, he was in charge of projects from San Diego to Humboldt Bay. These include, but are not limited to, the construction of a fort at Alcatraz Island, the fortification at Lime Point, the improvement of San Diego, Oakland, Wilmington (now San Pedro), and Humboldt Bay harbors, and improvements to the Sacramento, Feather, San Joaquin rivers and the Petaluma Creek. Mendell actively participated in the design of many of these projects and often employed innovative construction or demolition techniques. Concurrent with his military duties, Mendell was also involved as Engineer of the Water Commission for the city of San Francisco and produced a report on the various projects for the water supply of the city in 1877. He was considered a

[73] Hagwood, 52.

[74] Stewart Sifakis, *Who Was Who in the Civil War*. New York and Oxford: Facts on File Publications, 1988,444.

[75] Hagwood, 32.

leader in the engineering profession and served as the first president of the Technical Society of the Pacific Coast after its founding in 1884. His relationship with the city of San Francisco continued after his retirement and he was named President of the Board of Public Works in January, 1900, serving in this capacity until his death on October 17, 1902, in San Francisco.

As a member of the Board of Engineers which was constituted for the purpose of making the examination, survey and plan of a harbor at San Antonio Creek, California , Colonel G.H. Mendell, along with Lieutenant Colonel B.S. Alexander and Lieutenant Colonel C. S. Stewart, was instrumental in the development of a plan for Oakland's harbor. Even before Oakland's harbor was a Corps project, Mendell consulted with Oakland City Engineer W.H. Boardman on the feasibility of such a project and Mendell's support assisted local efforts in seeking federal funding for the project.[76]

Colonel G.H. Mendell had a lasting effect on the history of the Bay Area and California. His engineering expertise was well recognized in his lifetime and in 1929 Otto von Geldern called him "an erudite gentleman of the old school" who possessed "a deep theoretical knowledge, and his reports, which dealt with the important problems of the rivers and harbors of the Pacific Coast are well worth reading today."[77]

Although Colonel Mendell was already a distinguished military officer because of his service with the Engineers in the Civil War and his translation from the French (with W.P. Craighill) of Baron Henri Jomini's *The Art of War* (1862), his greatest contributions came during his tenure as San Francisco District Engineer and Pacific Division Engineer in the Army Corps of Engineers. He held the District Engineer position for twenty-four years, which is by far the longest tenure in the history of the San Francisco District, and was Division Engineer for five years. Among the many projects directed by Mendell, the Oakland Harbor training walls remain an excellent example of his engineering abilities.

Summary

The Oakland Harbor training walls are closely associated with the opening of the harbor to ocean-going vessels. Annual commerce entering or leaving the harbor increased from 154,000 tons in 1874 to about 3.25 million tons by 1900. Combined with other harbor improvements, the north training wall has contributed significantly to the growth of Oakland since the late 19th century.

The north training wall embodies distinctive characteristics of 19th century masonry construction. The dry-laid masonry facing is unique, in that most similar structures are rubble or rip-rap walls, and it represents a rare extant example of 19th-century workmanship in maritime structure. The north training wall is also associated with technological advances in dredging. Hydraulic dredging and landfill experiments during Oakland's initial harbor improvement project demonstrated the efficiency and economy of hydraulic suction dredges and pipeline disposal of dredged sediments for distances up to

[76] Henry, 1.

[77] von Geldern, 597. In 1929, Mr. von Geldern was a consulting engineer in San Francisco, life member of the American Society of Civil Engineers, Past President of the Astronomical Society of the Pacific, a Vice President of the California Academy of Sciences, President of the Mechanics Institute of San Francisco, and a Regent of the University of California.

4600 feet, which were unprecedented without the aid of a booster pump. As a result, similar machines were used in conjunction with harbor and land-fill projects by engineers in California, on the East Coast, and around the world. The construction of the training walls and channel instituted a pattern of development by which hundreds of acres of landfill were deposited between 1874 and 1946. Finally, the Oakland Inner Harbor North Training Walls and Federal Channel are associated with the work of Colonel George Henry Mendell, San Francisco District Engineer from 1871-1895, and a respected expert in the field of engineering on the Pacific Coast. Under the direction of Colonel Mendell, navigational improvements were initiated statewide in California. Oakland Harbor remains one of the best examples of Mendell's California engineering projects. The significance of the north training wall has extended into the present because most improvements at the Port of Oakland have taken place in reference to the established channel, as delineated by the north and south training walls.

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List of Figures:

V. PROJECT INFORMATION

This documentation has been prepared at the request of the Port of Oakland, which is proposing to demolish the Oakland Harbor North Training Wall for an expansion of its marine terminal facilities. A component of the plan is the construction of two 50-yard-long training walls, using material salvaged from the demolished north training wall, at a location along the shoreline of the public access area currently being planned for the Middle Harbor area. These walls will be constructed by the Dry Stone Masonry Conservancy in a manner faithful to the original construction techniques and will be interpreted for the public through signage.

Project manager for the documentation was Loretta Meyer of Lamphier & Associates. Written documentation was prepared by Celia McCarthy, Cultural Resources Planner, Port of Oakland, and edited by Woodruff C. Minor, Berkeley, California. The photographer was David G. DeVries of Mesa Technical, Berkeley, California. Written documentation is based on the National Register of Historic Places nomination prepared by Celia E. McCarthy and Richard Lerner (1997), on contextual working papers prepared by Michael R. Corbett and Woodruff C. Minor (1997), and on additional research.

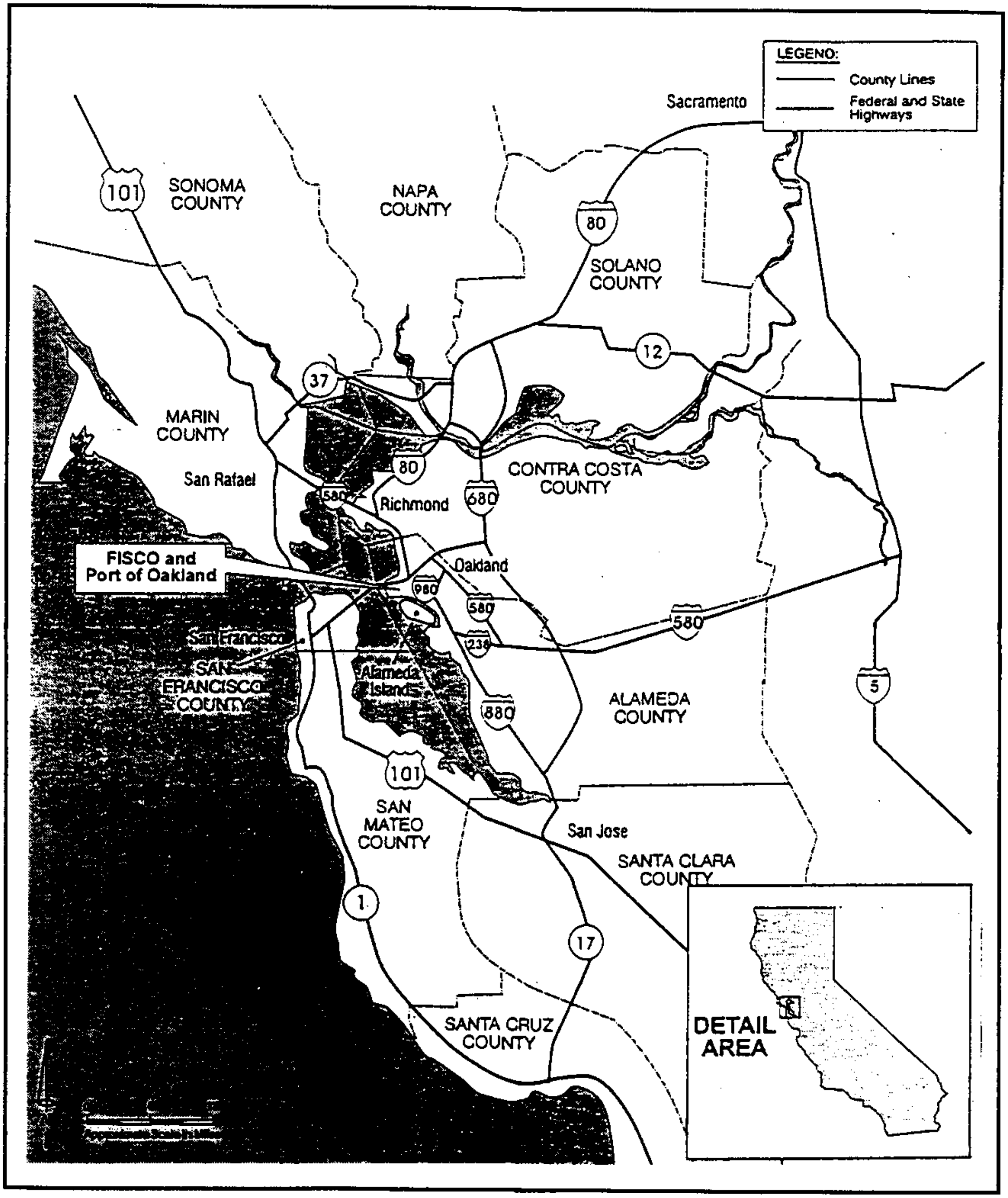

Figure 1– Regional Location from United States Department of the Navy and Port of Oakland. Vol. 1, Figure 1-1. July 1997.

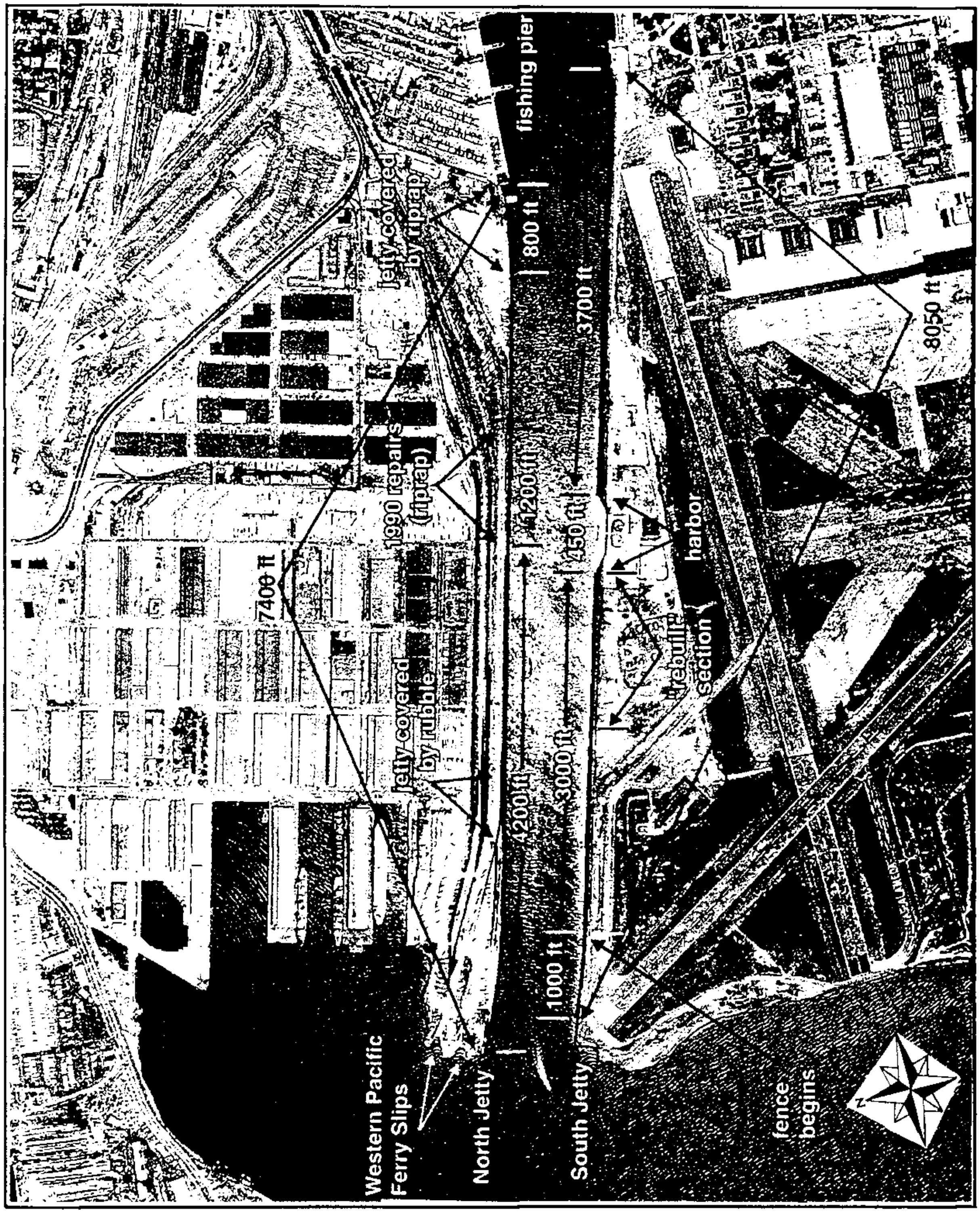

Figure 2 – Site Plan showing current length and condition of the Oakland Harbor North Training Wall (North Jetty) from McCarthy & Lerner 1997.

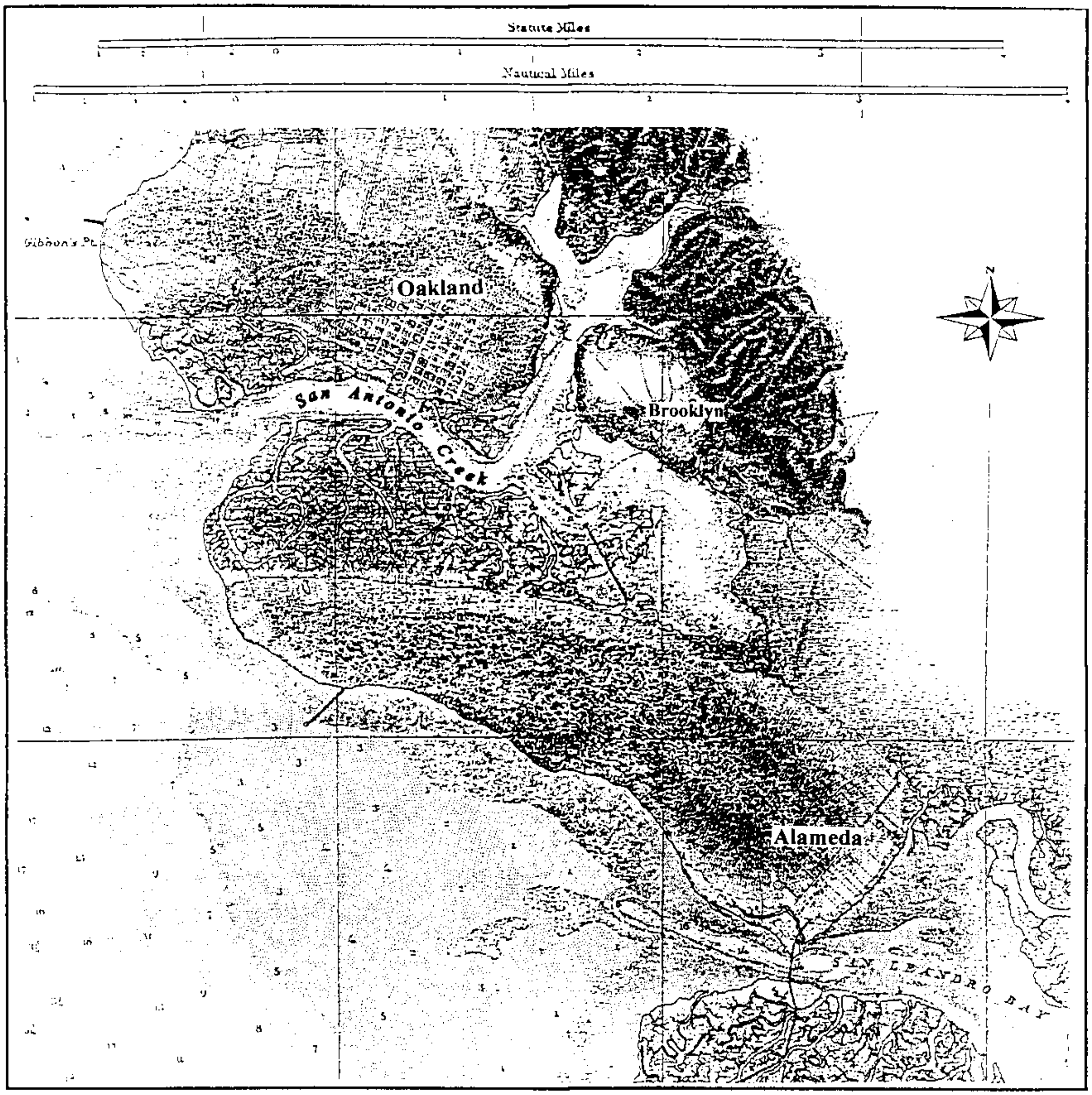

Figure 3 – San Antonio Creek from United States Coast Survey, *Entrance to San Francisco Bay California,* Washington, D.C.: The Survey, 1859 –adapted by Port of Oakland 1999.

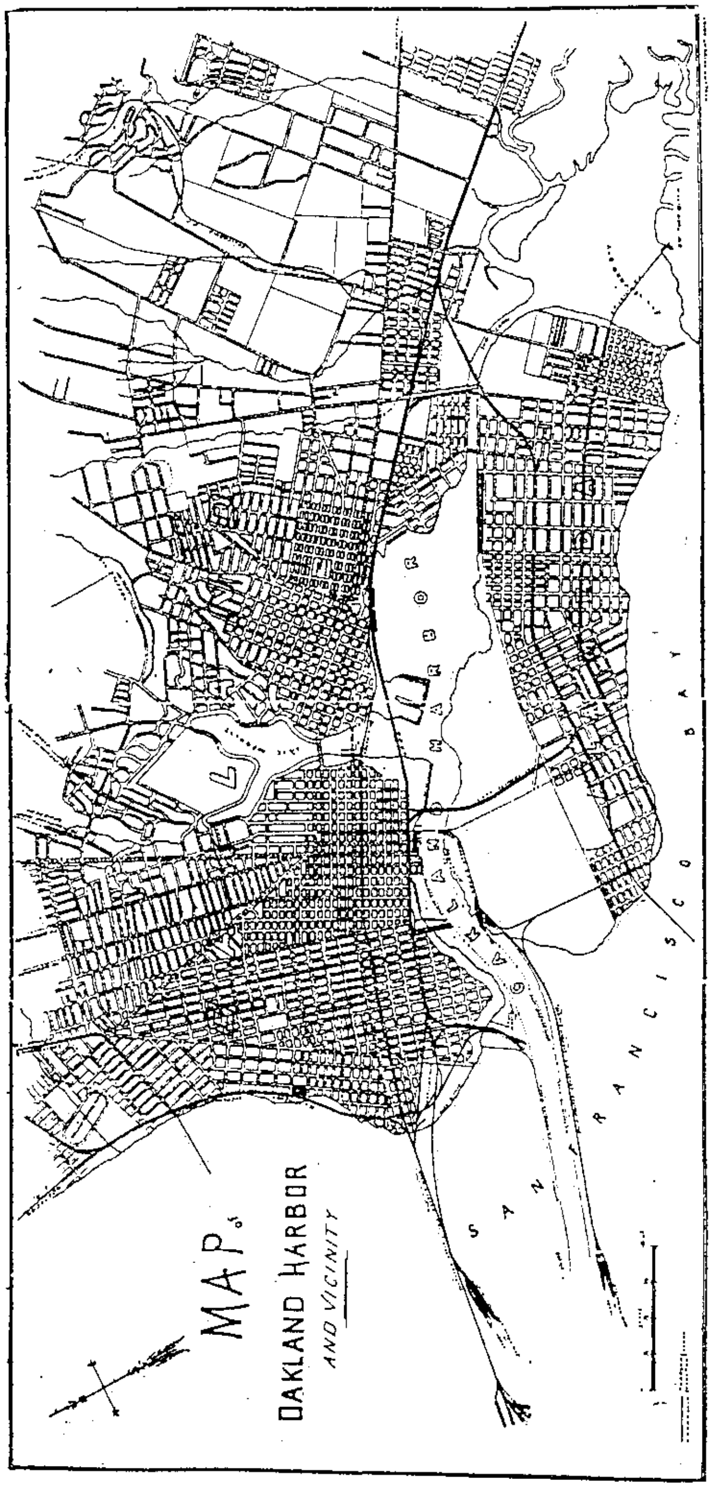

Figure 4. Map of Oakland Harbor and Vicinity, Oakland: Oakland Tribune 1894.

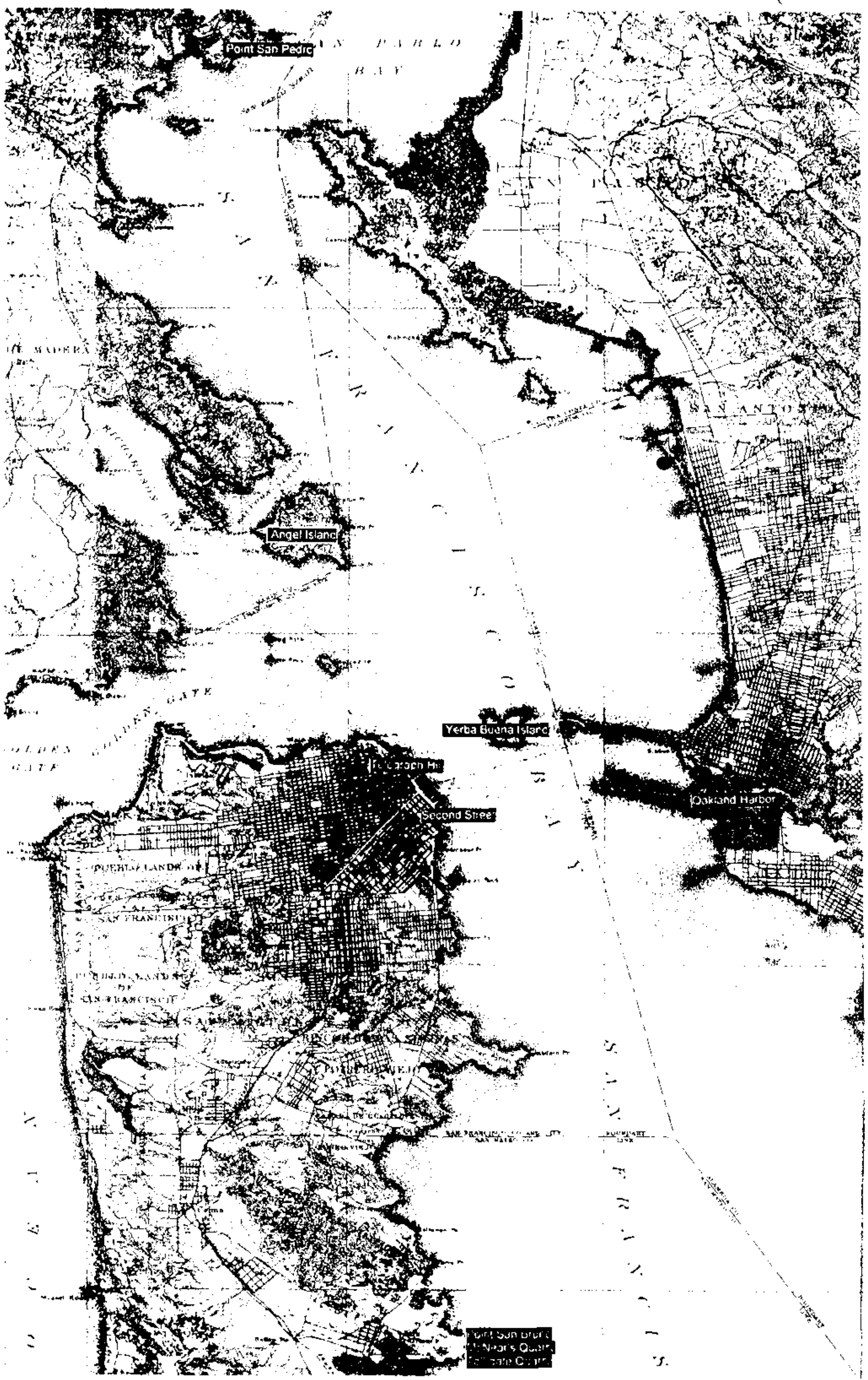

Figure 5 – Quarry locations from composite USGS 1899 Tamalpais, San Mateo, and San Francisco Quadrangles – adapted by Port of Oakland 1999.

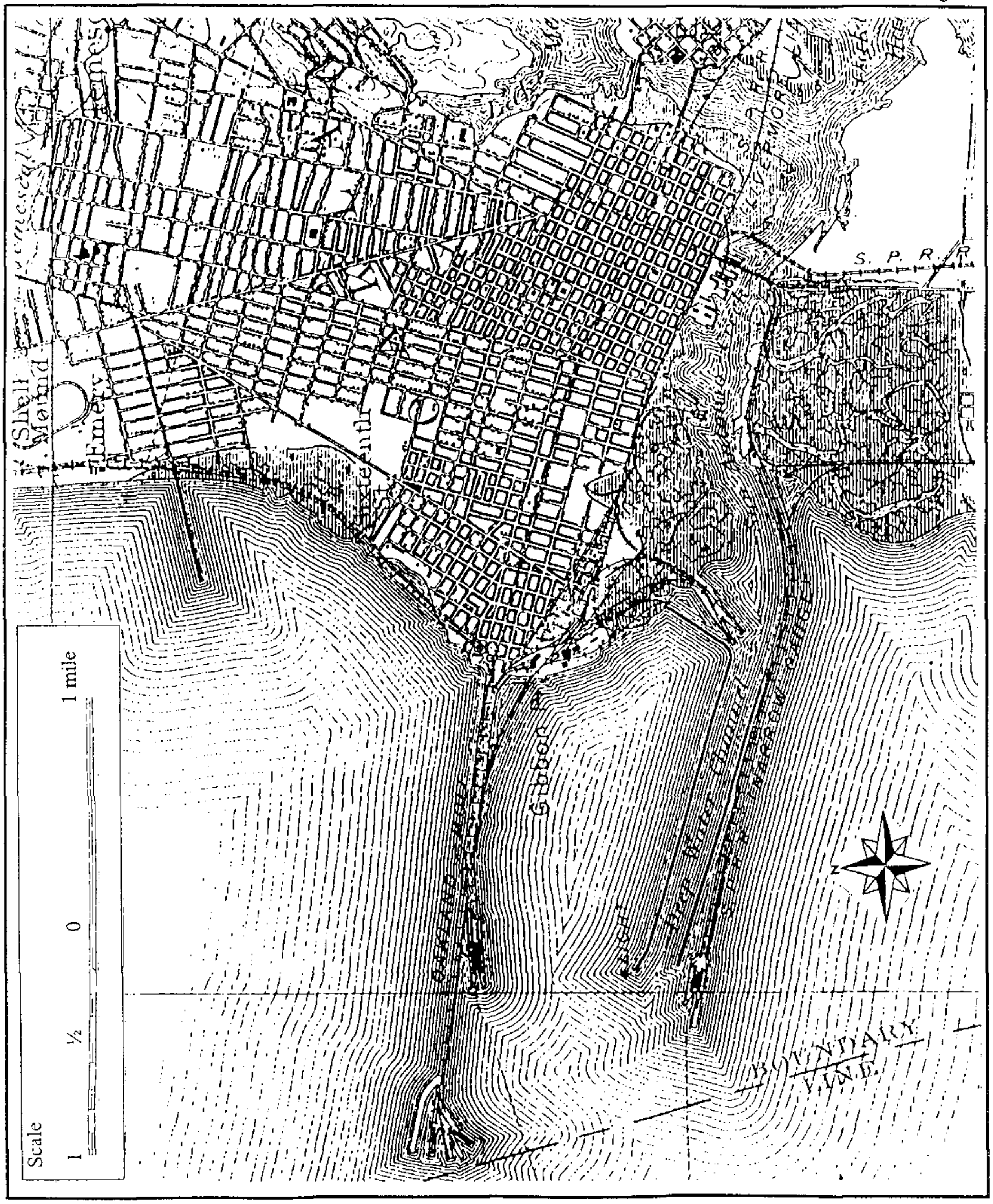

Figure 6 – USGS 1899 San Francisco Quadrangle

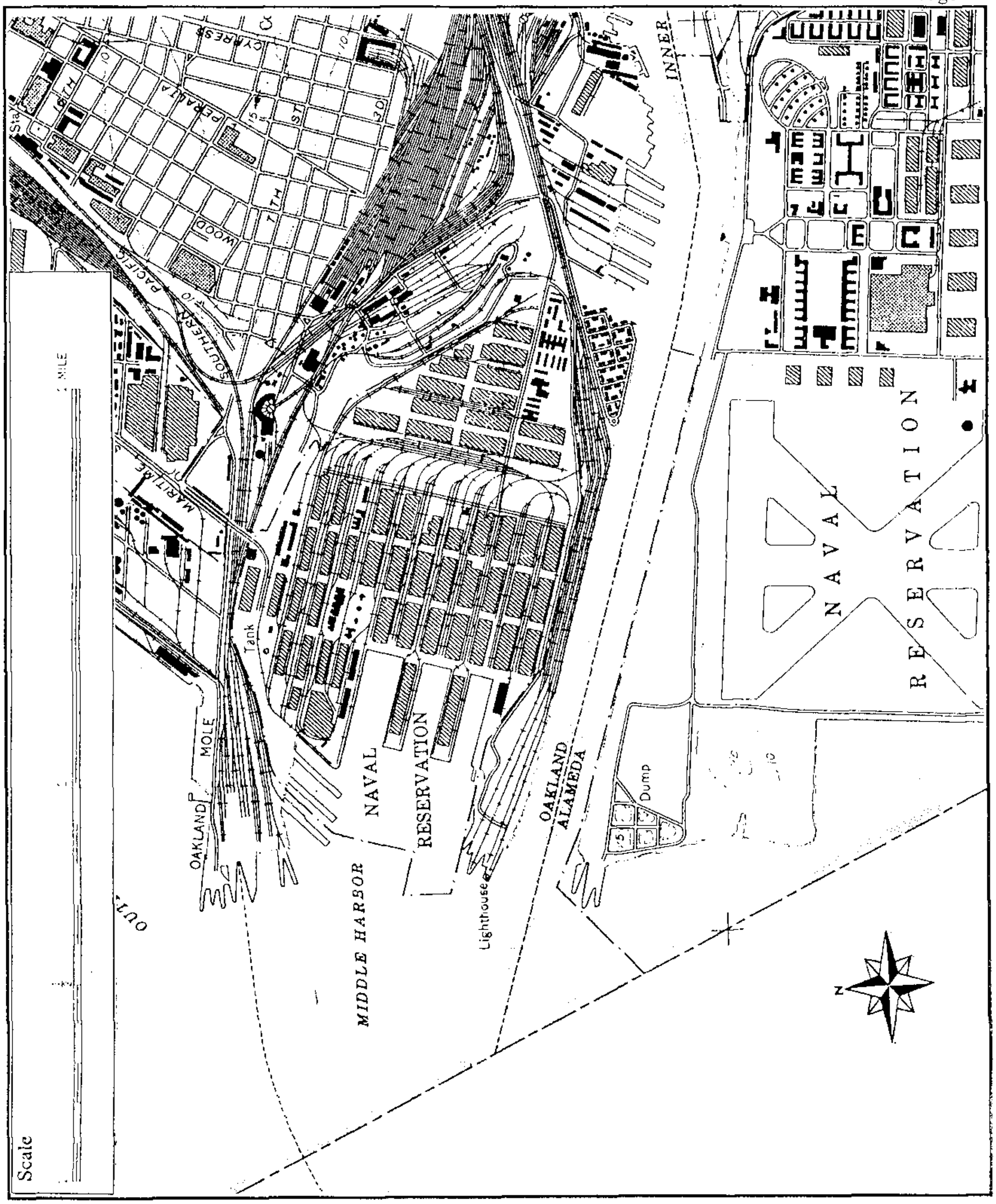

Figure 7 – USGS 1949 Oakland West Quadrangle

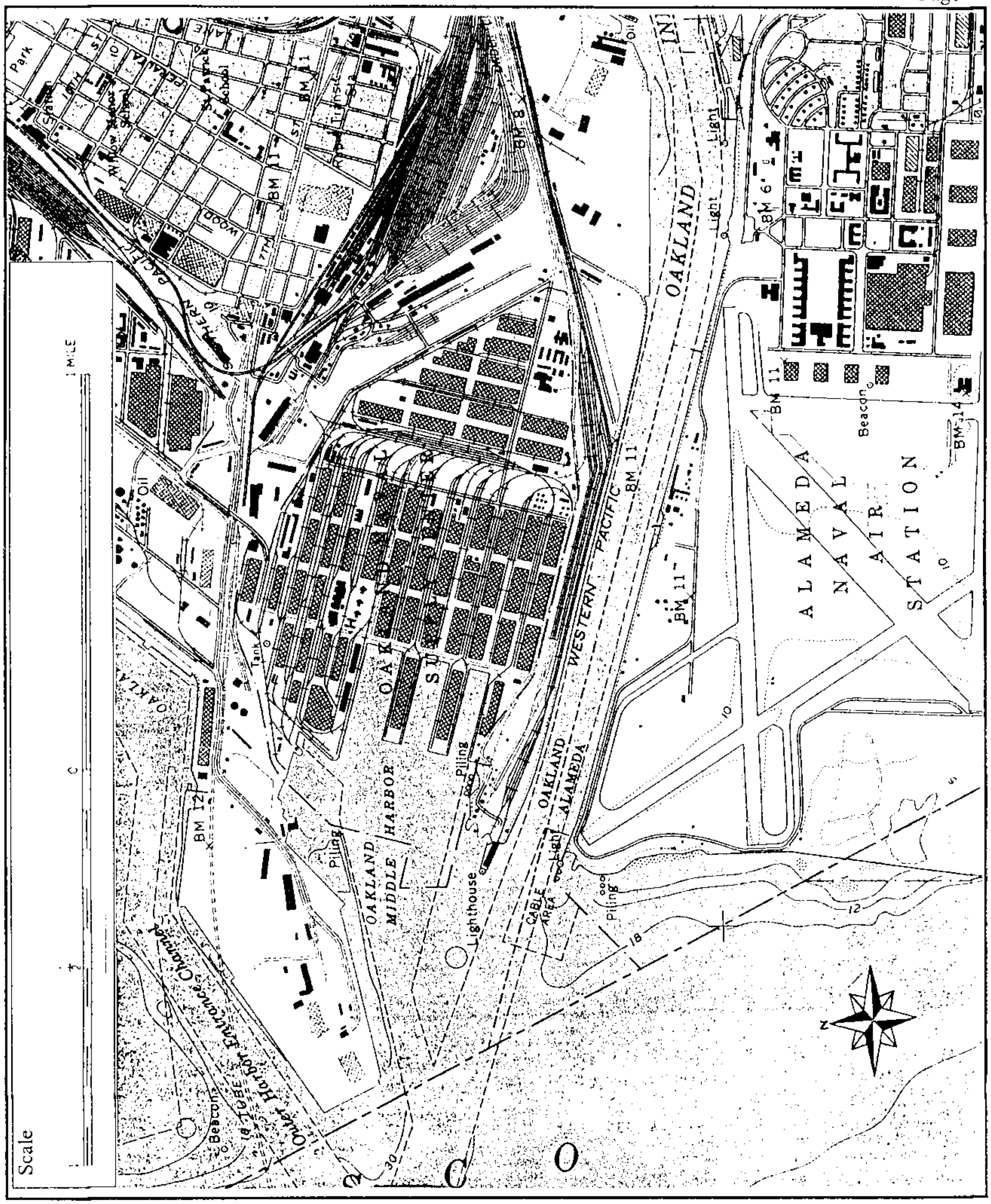

Figure 8 – USGS 1980 Oakland West Quadrangle